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TR 67-73

TECHNICAL REPORT NO. 67-73

OPERATION OF THE UINTA BASIN SEISMOLOGICAL OBSERVATORY

Quarterly Report No. 6

1 August through 31 October 1967

GEOTECH

A TELEDYNE COMPANY

TECHNICAL REPORT NO. 67-73

OPERATION OF THE UINTA BASIN SEISMOLOGICAL OBSERVATORY, QUARTERLY REPORT NO. 6

1 August through 31 October 1967

Sponsored by

Advanced Research Projects Agency
Nuclear Test Detection Office
ARPA Order No. 624

TELEDYNE INDUSTRIES
GEOTECH DIVISION
3401 Shiloh Road
Garland, Texas

15 November 1967

IDENTIFICATION

AFTAC Project No:	VF A T/6705
Project Title:	Operation of UBSO
ARPA Order No:	624
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Name of Contractor:	Teledyne Industries Geotech Division Garland, Texas
Date of Contract:	1 May 1966
Amount of Contract:	$624,897
Contract Number:	AF 33(657)-16563
Contract Expiration Date:	31 October 1967
Program Manager:	B. B. Leichliter, BR1-2561 Garland, Texas

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ILLUSTRATIONS

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TABLES

ABSTRACT

This report describes the operation of the Uinta Basin Seismological Observatory (UBSO) from 1 August through 31 October 1967. Modifications and additions to the observatory instrumentation are described, and tests to improve the operations of the observatory are reported. Also discussed is the status of special investigations designed to evaluate and improve the detection capability of the observatory.

OPERATION OF UBSO - QUARTERLY REPORT NO. 6
1 AUGUST 1967 THROUGH 31 OCTOBER 1967

1. INTRODUCTION

1.1 AUTHORITY

The work described in this report was supported by the Advanced Research Projects Agency, Nuclear Test Detection Office, and was monitored by the Air Force Technical Applications Center (AFTAC), under Contract AF 33(657)-16563. The statement of work for this contract is shown in the appendix.

1.2 HISTORY

The Uinta Basin Seismological Observatory (UBSO) was constructed under Contract AF 33(657)-7185. Site selection and noise surveys were accomplished by Geotech; the final decision on the observatory location was made by AFTAC. Texas Instruments Incorporated (TI) was responsible for the construction of all physical facilities.

2. OPERATION OF UBSO

2.1 GENERAL

Data are recorded at UBSO on a 24-hour basis. The observatory is normally manned 8 to 10 hours a day, 5 days a week. On weekends and holidays, a skeleton crew mans the observatory 8 hours a day; however, additional personnel are on call in case of emergency.

The UBSO array configuration is shown in figure 1.

The Project Officer and the Geotech Program Manager visited UBSO on 28 and 29 September to discuss plans for the long-period array.

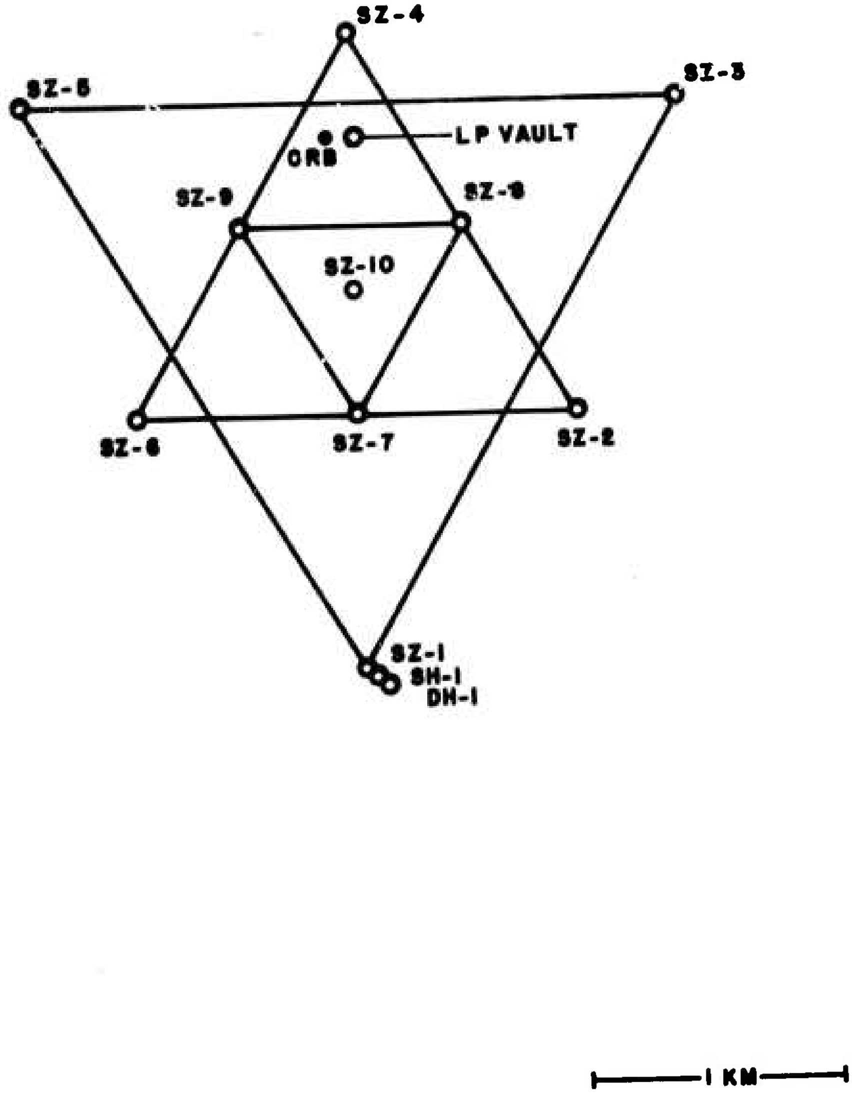

Figure 1. Orientation and configuration of UBSO arrays

2.2 SEISMOGRAPH OPERATING PARAMETERS

2.2.1 Standard Seismographs

The operating parameters and the tolerances for the standard observatory seismographs are shown in table 1. These parameters are reset if the frequency response of a seismograph is found to be out of tolerance. The frequency response norms and their respective tolerances are shown in table 2. The frequency responses of the UBSO seismographs, as normally operated, are shown in figure 2.

2.2.2 Filters for Multichannel Array Processors (MAP)

All MAP channels utilize a band-pass filter with the following settings: a high-cut corner frequency of 3 cps at 6 dB per octave cutoff rate, and a low-cut corner frequency of 1 cps at 12 dB per octave cutoff rate.

2.2.3 Filters for Shallow-Buried Array Summations

The summation of the ten-element shallow-buried array is filtered by a band-pass filter with the following settings: a high-cut corner frequency of 3 cps and a low-cut corner frequency of 0.8 cps, both at a cutoff rate of 18 dB per octave.

2.2.4 Filters for Vertical Array Summations

The vertical array was inoperative during this quarter because of a faulty cable. A new cable is scheduled to be sent to UBSO when it is available as Government furnished equipment. Prior to 1 July, the summation output of the vertical array was filtered as follows: a high-cut corner frequency of 3 cps at a cutoff rate of 24 dB per octave and a low-cut corner frequency of 0.75 cps at a cutoff rate of 36 dB per octave.

2.3 DATA CHANNEL ASSIGNMENTS

The current data-channel assignments and normal operating magnifications for all UBSO data groups are shown in table 3. The key to the designators used in the data-channel assignments is given in table 4.

2.4 COMMERCIAL POWER FAILURES AND DATA OUTAGES

Failures of commercial power occurred on 6, 11, 12, and 13 August; 11 and 12 September; and 6 October. No loss of data resulted from the August failures or from the failure on 11 September. The failure on 12 September lasted for 2 hours and 22 minutes. The emergency systems functioned

Table 1. Operating parameters and tolerances of seismographs at UBSO

Seismograph		Seismometer		Operating parameters and tolerances					Filter settings	
System	Comp	Type	Model	T_s	λ_s	T_g	λ_g	σ^2	Bandpass at 3 dB cutoff (sec)	Cut off rate at SP side (dB/oct)
SP	Z and H	Johnson Matheson	7515, 6480	1.25 ±2%	0.51 ±5%	0.33 ±5%	0.65 ±5%	0.03	0.1-100	12
SP	SZ	Geotech	18300	1.25 ±2%	0.51 ±5%	0.33 ±5%	0.65 ±5%	0.053	0.1-100	12
SP	Z	UA Benioff	1051	1.0 ±5%	1.0	0.083 ±5%	≈1.4	1.0	-	-
IB	Z	Melton	10012	2.5 ±5%	0.65 ±5%	0.64 ±5%	1.2 ±5%	0.018	0.05-100	12
IB	H	Geotech	8700B	2.5 ±5%	0.65 ±5%	0.64 ±5%	1.2 ±5%	0.001	0.05-100	12
BB	Z	Geotech	7505	12.5 ±5%	0.485 ±5%	0.64 ±5%	9.0 ±5%	0.0007	0.05-100	12
BB	H	Geotech	8700A	12.5 ±5%	0.485	0.64 ±5%	9.0 ±5%	0.0007	0.05-100	12
LP	Z	Geotech	7505A	20.0 ±5%	0.74 ±5%	110 ±10%	0.85 ±10%	0.63	25-1000	12
LP	H	Geotech	8700A	20.0 ±5%	0.74 ±5%	110 ±10%	0.85 ±10%	0.63	25-1000	12

KEY

SP	Short period	T_s	Seismometer free period (sec)
IB	Intermediate band (currently inactive)	T_g	Galvanometer free period (sec)
BB	Broad band	λ_s	Seismometer damping constant
LP	Long period	λ_g	Galvanometer damping constant
UA	Unamplified (i.e., earth powered)	σ^2	Coupling coefficient

Table 2. Calibration norms and operating tolerances for frequency responses of the standard seismographs at UBSO

SP Vertical 18300 and
SP Johnson-Matheson
Vertical and Horizontal

f (cps)	T (sec)	R. M.	A. T. (±%)
0.2	5.0	0.0113	10
0.4	2.5	0.0950	7.5
0.8	1.25	0.685	5
1.0	1.0	1.0	-
1.5	0.67	1.52	5
2.0	0.5	1.90	5
3.0	0.33	2.12	7.5
4.0	0.25	1.87	12
6.0	0.167	1.15	20
8.0	0.125		
10.0	0.100		

LP Vertical and Horizontal [c]

f (cps)	T (sec)	R. M.	A. T. (±%)
0.01	100	0.246	20
0.0125	80	0.377	20
0.0167	60	0.589	15
0.02	50	0.745	15
0.025	40	0.899	10
0.033	30	1.06	5
0.04	25	1.0	-
0.05	20	0.822	5
0.0667	15	0.506	10
0.10	10	0.173	20
0.143	7	b	a

IB Vertical and Horizontal

f (cps)	T (sec)	R. M.	A. T. (±%)
0.1	10.0	0.0090	25
0.2	5.0	0.068	20
0.3	3.3	0.25	15
0.4	2.5	0.46	10
0.5	2.0	0.64	5
0.7	1.43	0.86	5
1.0	1.0	1.0	-
1.5	0.67	1.04	5
2.0	0.5	1.0	10
3.0	0.33	0.89	15
5.0	0.2	0.66	20

BB Vertical and Horizontal

f (cps)	T (sec)	R. M.	A. T. (±%)
0.04	25.0	0.104	20
0.06	16.7	0.350	20
0.08	12.5	0.775	15
0.1	10.0	0.950	10
0.2	5.0	1.0	5
0.4	2.5	1.0	5
0.8	1.25	1.0	-
1.6	0.625	1.0	5
3.2	0.312	1.0	10
6.4	0.156	0.980	15

KEY

R. M.	Relative magnification
A. T.	Amplitude tolerance
a	Tolerance not established in the period
b	Measurements not reliable due to interference from microseismic background noise
c	These norms and tolerances apply to the broad-response, long-period system (LP1).

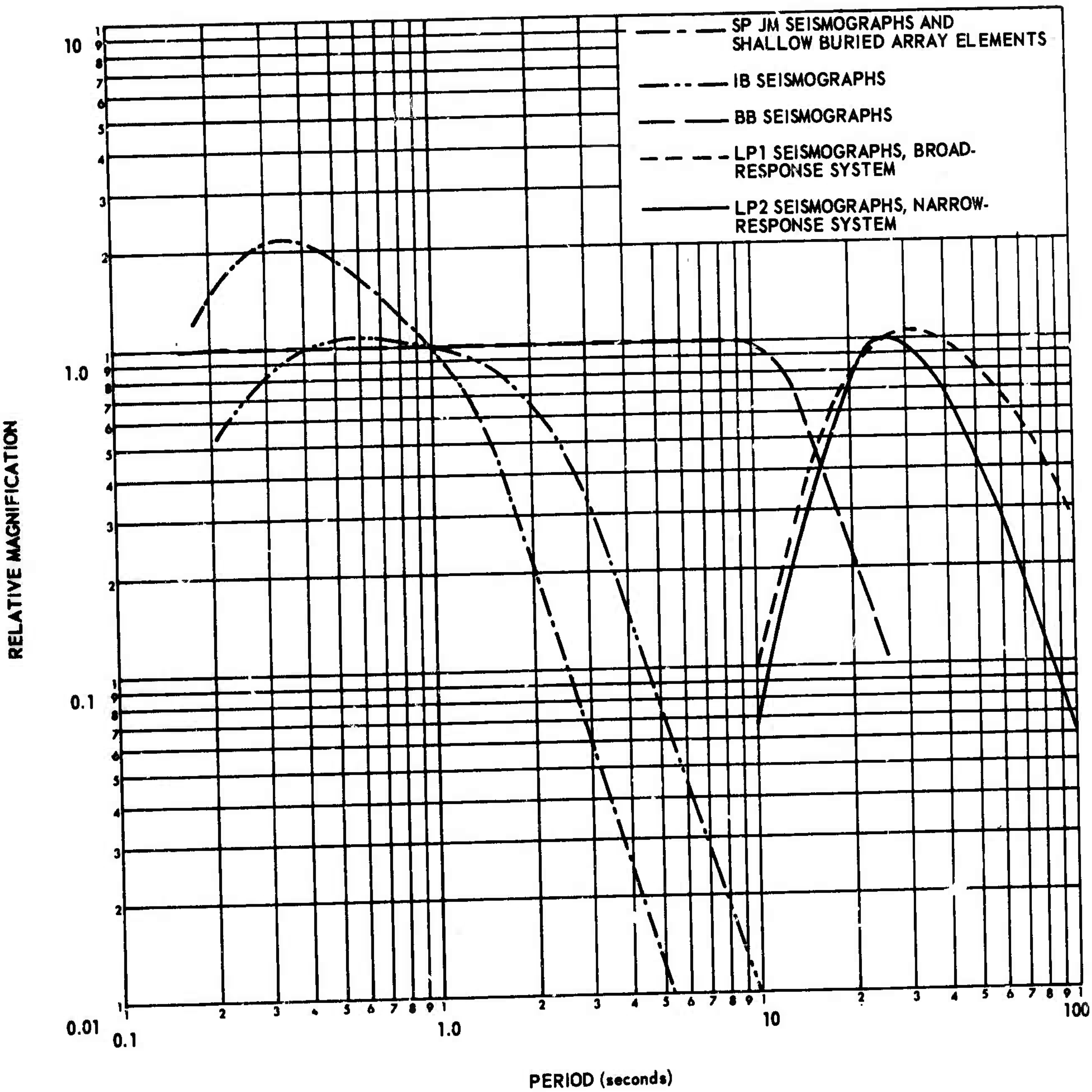

Figure 2. Normalized response characteristics of the standard seismographs at UBSO

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Table 3. Data channel assignments and normal operating magnifications at UBSO

DEVELOCORDERS

FAST SPEED 30mm/min.

DATA GROUP 5044 SP Primary

Channel	Trace	Mag.
1	V	20K
2	SZ1	600K
3	SZ3	600K
4	SZ5	600K
5	SZ2	600K
6	SZ4	600K
7	SZ6	600K
8	SZ7	600K
9	SZ8	600K
10	SZ9	600K
11	ΣSSF	6000K
12	ΣSS	1500K
13	SZ10	600K
14	NSP	600K
15	ESP	600K
16	WWV	---

DATA GROUP 5064

Channel	Trace	Mag.
1	V	2K
2	MS1	0.75μb/mm
3	MS2	0.75μb/mm
4	DH6	1000K
5	DH5	1000K
6	DH4	1000K
7	DH3	1000K
8	DH2	1000K
9	DH1	1000K
10	ΣDHF	6000K
11	ΣDH	1500K
12	SZ8	600K
13	USO-SP	---
14	USO-Time	---
15	$W1 \frac{3\ mph/mm}{S = 0/8\ mm\ (E = 6)}$	
16	WWV	---

DATA GROUP 5076

Channel	Trace	Mag.
1	SZ10L	60K
2	NSPL	60K
3	ESPL	60K
4	Z10LL	5K
5	NSPLL	5K
6	ESPLL	5K
7	SZ1	600K
8	SZ3	600K
9	SZ5	600K
10	ΣSSF	6000K
11	ΣSS	1500K
12	Z10	600K
13	NSP	600K
14	ESP	600K
15	TCDMG (Tape #1)	---
16	WWV	---

DATA GROUP 5072 MAP II

Channel	Trace	Mag.
1	Test	---
2	MCF11	Testing
3	MCF12	Testing
4	MCF13	Testing
5	MCF14	Testing
6	MCF15	Testing
7	MCF16	Testing
8	MCF17	Testing
9	BSSV1	Testing
10	BSSV2	Testing
11	BSSV3	Testing
12	BSSV4	Testing
13	BSSV5	Testing
14	BSSV6	Testing
15	ΣDVS	Testing
16	WWV	-----

SLOW SPEED 3mm/min.

DATA GROUP 5074

Channel	Trace	Mag.
1	$W1 \frac{3\ mph/mm}{S = 0/8\ mm\ (E = 6)}$	
2	SZ2	300K
3	ZLP1	25K
4	NLP1	25K
5	ELP1	25K
6	ZLP2	100K
7	NLP2	100K
8	ELP2	100K
9	ML1	3μb/mm
10	ML2	3μb/mm
11	USO -	LP -
12	ZBB	1.0K
13	NBB	1.0K
14	EBB	1.0K
15	WWV	
16	-----	

MAGNETIC TAPE RECORDERS

DATA GROUP 5029 No. 1

Channel	Trace
1	TCDMG
2	DH1
3	DH2
4	DH3
5	DH4
6	DH5
7	Comp.
8	DH6
9	ΣDH
10	ΣDHF
11	Z10LL
12	NSPLL
13	ESPLL
14	WWV & Voice

DATA GROUP 5023 No. 2

Channel	Trace
1	TCDMG
2	ZBB
3	NBB
4	EBB
5	NSP
6	ESP
7	Comp.
8	ZLP1
9	NLP1
10	ELP1
11	ZLP2
12	NLP2
13	ELP2
14	WWV & Voice

DATA GROUP 5025 No. 3

Channel	Trace
1	TCDMG
2	SZ1
3	SZ2
4	SZ3
5	SZ4
6	SZ5
7	Comp.
8	SZ6
9	SZ7
10	SZ8
11	SZ9
12	SZ10
13	ΣSS
14	WWV & Voice

DATA GROUP 5035 No. 4

Channel	Trace
1	TCDMG
2	USOZSP
3	USOZLP
4	USO Time
5	ΣSSF
6	MCF11
7	Comp.
8	MCF12
9	MCF13
10	
11	
12	
13	
14	WWV & Voice

Table 4. Key to the designations used in the data format assignments at UBSO

Z	Amplified vertical short-period seismograph from a surface site identified by a suffix number
SZ	Amplified vertical short-period seismograph from a shallow-buried site identified by a suffix number
NSP	Amplified north-south short-period seismograph
ESP	Amplified east-west short-period seismograph
V	Unamplified vertical short-period seismograph
ZLP1	Vertical long-period seismograph, broad response
NLP1	North-south long-period seismograph, broad response
ELP1	East-west long-period seismograph, broad response
ZLP2	Vertical long-period seismograph, narrow response
NLP2	North-south long-period seismograph, narrow response
ELP2	East-west long-period seismograph, narrow response
ZBB	Vertical broad-band seismograph
EBB	East-west broad-band seismograph
ΣS	Summation of Z1 through Z10
ΣSF	ΣS filtered
ΣSS	Summation of SZ1 through SZ10
ΣSSF	ΣSS filtered
DH1	Vertical-array element at 8895 feet
DH2	Vertical-array element at 7903 feet
DH3	Vertical-array element at 6910 feet
DH4	Vertical-array element at 5894 feet
DH5	Vertical-array element at 4901 feet
DH6	Vertical-array element at 3907 feet
ΣDH	Summation of DH1 through DH6
ΣDHF	ΣDH filtered
ML1	Long-period microbarograph (inside LP vault)
ML2	Long-period microbarograph (outside LP vault)
MS1	Short-period microbarograph (inside LP vault)

Table 4. Continued

NBB	North-south broad-band seismograph
WWV	Radio time (WWV, STS, and voice on tape)
Test	Test instrumentation
Comp	Compensation
Mag	Magnification (see note)
TCDMG	Time code data management group
USO-SP	Unmanned seismological observatory short-period seismograph
USO-LP	Unmanned seismological observatory long-period seismograph
MCF1	Multichannel filter: ∞velocity signal and measured noise correlations (not including road noise) using Z1 - Z10
MCF3	Multichannel filter: 8.1 ∞km/sec velocity signal and measured noise correlations (not including road noise) using Z1 - Z10
MCF4	Multichannel filter: ∞velocity signal and measured noise correlations (including road noise), using Z1 - Z10
ΣSBS	Summation of Z1 - Z10, with MAP band-pass filter
MS2	Short-period microbarograph (outside LP vault)
WI	Anemometer-wind speed and direction
BSS3	Beam-steered summation: 8.1 km/sec signal from azimuth of 120°, using Z1 - Z10
BSS4	Beam-steered summation: 8.1 km/sec signal from azimuth of 180°, using Z1 - Z10
BSS5	Beam-steered summation: 8.1 km/sec signal from azimuth of 240°, using Z1 - Z10
BSS6	Beam-steered summation: 8.1 km/sec signal from azimuth of 300°, using Z1 - Z10
MCF11	Multichannel filter: ∞velocity signal and measured noise correlations (not including road noise), using SZ1 - SZ10
MCF12	Multichannel filter: ∞velocity signal and theoretical noise model, using SZ1 - SZ10 and DH1-DH6
MCF13	Multichannel filter: ∞velocity signal and theoretical noise model, using DH1 - DH6
MCF14	Deghost filter: up-going ∞velocity P-wave signal and theoretical noise model, using DH1, DH3, and DH5

Table 4. Continued

BSS1	Beam-steered summation: 8.1 km/sec signal from azimuth of 0°, using Z1 - Z10
BSS2	Beam-steered summation: 8.1 km/sec signal from azimuth of 60°, using Z1 - Z10
BSSV1	Beam-steered summation: up-going ∞velocity P-wave, using DH1 - DH6
BSSV2	Beam-steered summation: up-going 8.1 km/sec P-wave, using DH1 - DH6
BSSV3	Beam-steered summation: up-going 8.1 km/sec S-wave, using DH1 - DH6
BSSV4	Beam-steered summation: down-going ∞velocity P-wave, using DH1 - DH6
MCF15	Deghost filter: down-going ∞velocity P-wave signal and theoretical noise model, using DH1, DH3, and DH5
MCF16	Deghost filter: up-going ∞velocity P-wave signal and theoretical noise model, using DH2, DH4, and DH6
MCF17	Deghost filter: down-going ∞velocity P-wave signal and theoretical noise model, using DH2, DH4, and DH6
BSSV5	Beam-steered summation: down-going 8.1 km/sec P-wave, using DH1 - DH6
BSSV6	Beam-steered summation: down-going 8.1 km/sec S-wave, using DH1 - DH6
ΣDVS	Summation of SZ1 - SZ10 and DH1 - DH6, with MAP band-pass filter

NOTE

Magnification of:

Short-period measured at 1 cps
Broad-band measured at 0.8 cps
Long-period measured at 0.04 cps
MCF measured at 1 cps
BSS measured at 1 cps

properly, but all systems except the short-period primary data were shut down after 1 hour and 45 minutes of operation to conserve secondary power. On 6 October, a power failure resulted in the loss of data from all short-period seismographs for 3 hours and 30 minutes.

2.5 SHIPMENT OF DATA TO THE SEISMIC DATA LABORATORY (SDL)

Magnetic-tape seismograms are shipped to SDL about 15 days after the end of the month during which they are recorded. The seismograms from magnetic-tape recorders 1, 2, 3, and 4 recorded at UBSO through 30 September have been shipped to SDL.

All 16-millimeter film seismograms recorded at UBSO through 31 August were sent to SDL. More recent films are currently held in Garland for special studies.

2.6 QUALITY CONTROL

Quality control checks were ma on randomly selected runs of all recordings from the observatory. Results of the checks were sent to the observatory for corrective action as necessary.

2.7 SECURITY INSPECTION

On 5 September, UBSO was notified by Mr. William J. Robertson, Industrial Security Specialist, that because UBSO has no classified documents, his quarterly security inspection will be conducted by telephone in the future. This procedure will continue until such time that the observatory holds classified documents.

3. EVALUATE DATA AND PROVIDE MOST EFFECTIVE OBSERVATORY POSSIBLE

3.1 MODIFICATIONS TO INSTRUMENTATION AT UBSO

Modified hose clamps and roller assemblies were installed in the peristaltic pumps of the Develocorders during the report period. The only failure of a modified pump occurred on 22 October when both hoses were split in the pump of Develocorder 3.

On 9 October, the procedure for use of the emergency power system was modified. Because low priority data are being recorded on magnetic-tape recorders 1 and 4, these recorders are turned off during a failure of commercial power. With this load removed from the emergency system, the standby generator can handle the remaining load of all instrumentation, including both battery chargers. The new configuration was successfully tested when during a planned outage of commercial power, the emergency system operated for a total of 1 hour and 40 minutes.

On 30 October, Develocorder 6, which was formerly used for MAP 1, was modified for use in the recording of the long-period triaxial system and other long-period test systems.

3.2 ADDITIONS TO INSTRUMENTATION AT UBSO

3.2.1 Long-Period Triaxial Seismometer

The drilling and casing of a 200-foot hole to be used for the evaluation of the long-period triaxial seismometer was completed during August. The drilling and casing were conducted under Project VT/6706 and were coordinated by the UBSO personnel. All of the surface facilities for the long-period triaxial installation were completed during September. In October a cable trench was dug from the central recording building to the site of the long-period triaxial seismometer, poles for the installation of power to the storage building were set, and the power was installed.

3.2.2 Long-Period Array

Suitable sites for the six positions of the long-period array were found by test drilling. The locations of the six sites were surveyed, and Mr. Ray E. Book, U. S. Corps of Engineers, is currently negotiating with representatives of the Ute Indian Tribe and the Bureau of Land Management, State of Utah, for the lease of the sites.

4. TRANSMIT DAILY MESSAGES TO THE COAST AND GEODETIC SURVEY

The arrival time, period, and amplitude measurements for events recorded at UBSO were reported daily to the Director of the Coast and Geodetic Survey in Washington, D. C. The number of events, by type, reported by UBSO during each month in this reporting period is shown in table 5. Table 6 shows the total number of events recorded by the observatory, the number of epicenters determined by the C&GS and reported in the "Earthquake Data Report,"

Table 5. Events reported to the C&GS by UBSO during August, September, and October 1967

Month	Local	Near Regional	Regional	Teleseisms	Total
August	23	363	36	1256	1678
September	12	328	66	1171	1577
October	10	384	29	1224	1647

Table 6. Percentage of hypocenters reported in the C&GS "Earthquake Data Report" for which UBSO data were used

Month	No. events reported by UBSO	No. C&GS hypocenters	Percent of C&GS hypocenters for which the C&GS listed a UBSO P or PKP arrival	Percent of C&GS hypocenters for which UBSO recorded a P or PKP phase, based on associated data	Percent of C&GS hypocenters for which UBSO recorded a P, PKP, or later phase, based on updated associated data
April	1683	426	59.5	69.2	76.3
May	1659	413	67.9	70.9	76.3
June	1678	444	65.6	68.2	71.6

the percent of the C&GS hypocenters within 100 degrees of UBSO for which the C&GS report listed a UBSO P or PKP phase, the percent of C&GS hypocenters for which UBSO recorded a P or PKP phase, as determined from associated data, and the percent of C&GS hypocenters for which UBSO recorded a P, PKP, or later phase, based on updated associated data for April, May, and June. Lists of more recent epicenters have not been completed by the C&GS.

Figures 3 and 4 show the world-wide distribution of the C&GS-located epicenters for April, May, and June 1967. The three types of symbols used to show the locations of the epicenters represent the detection by UBSO of a P or PKP, the detection of an event in which the first recorded arrival was not P or PKP, and no detection.

5. PUBLISH MONTHLY EARTHQUAKE BULLETIN

5.1 BULLETIN STATUS

Data from UBSO were combined with data from BMSO, CPSO, TFSO, and WMSO and published in a multistation earthquake bulletin. The bulletins for April, May, and June 1967 were published and distributed during the reporting period. Raw data for July and August were keypunched, transcribed onto magnetic tape, and sent to SDL for association. The raw data for September were sent to SDL for keypunching and association.

5.2 TRANSFER OF KEYPUNCHING RESPONSIBILITY TO SDL

Beginning with the October 1967 raw data, the responsibility of bulletin keypunching was transferred to SDL. Checking and updating of the ABP output and publication of the bulletin will continue to be accomplished by Geotech.

6. MAINTAIN UBSO FACILITIES

The underside of the porch roof of the central recording building was repainted as were the tripod at the long-period vault, the top of the vault, and the multiconductor cable reel. Also, the back and borders of the UBSO "KEEP OUT" sign were repainted.

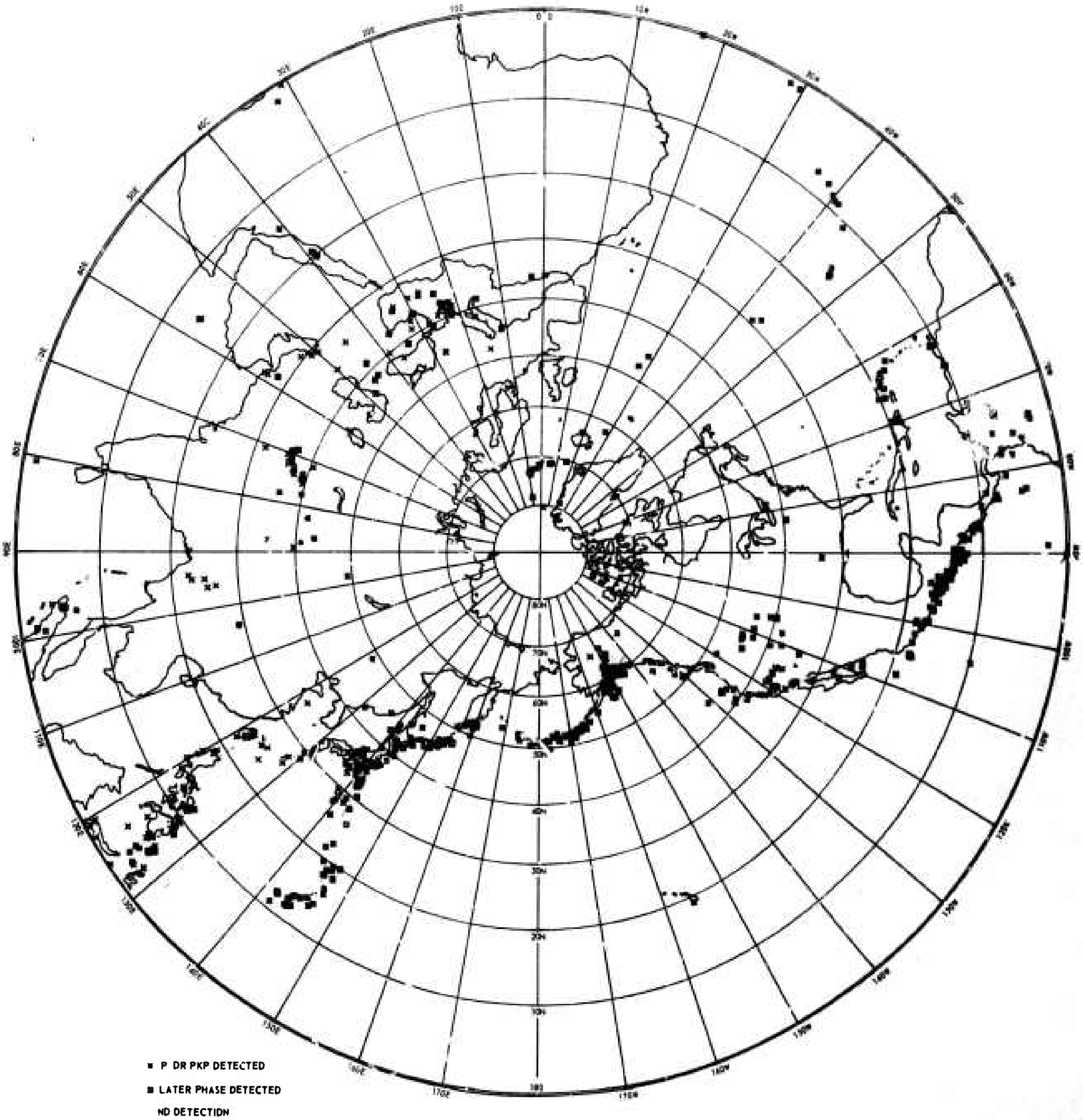

Figure 3. Distribution of Coast and Geodetic Survey located epicenters in the northern hemisphere for April, May, and June 1967

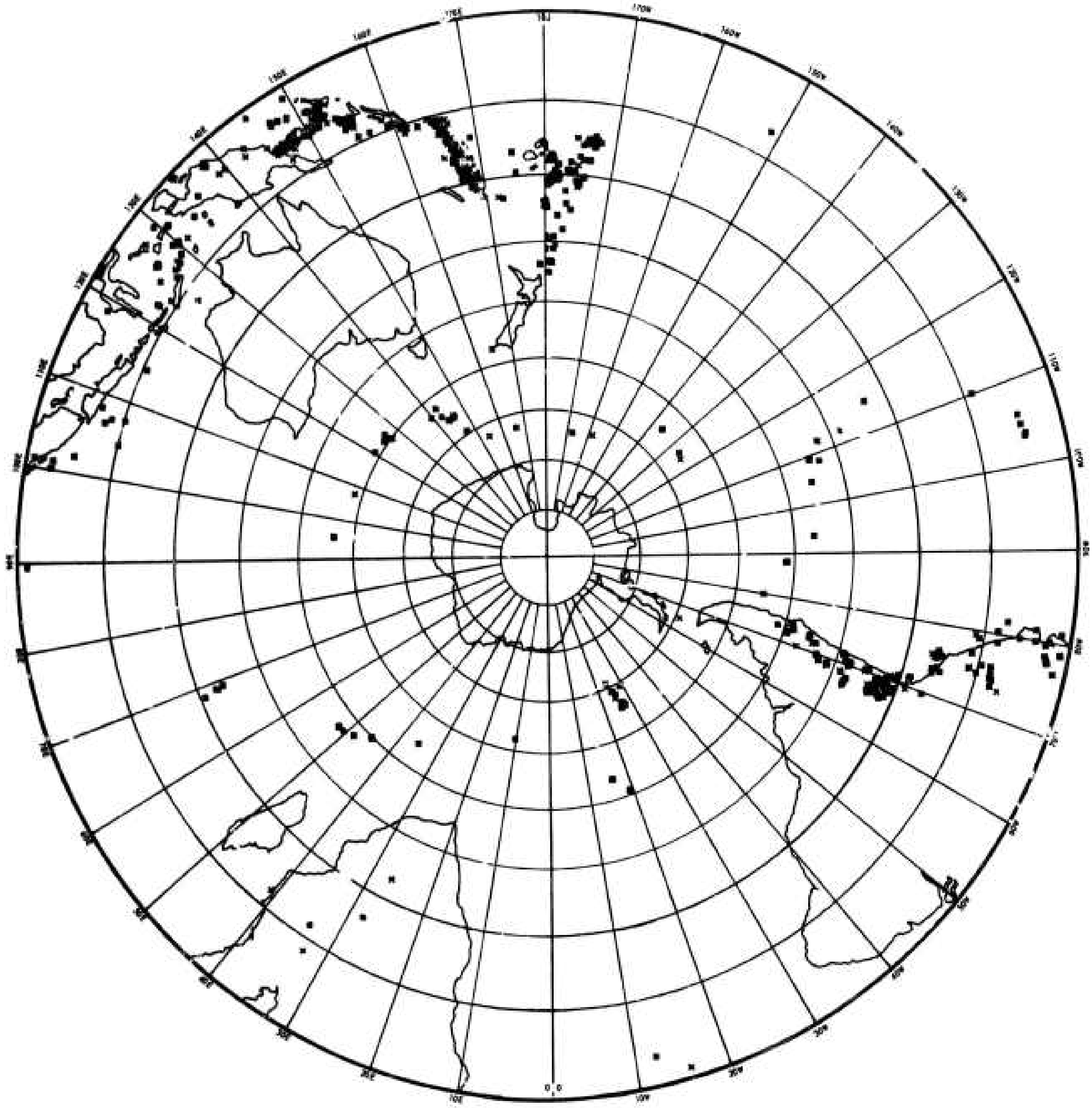

Figure 4. Distribution of Coast and Geodetic Survey located epicenters in the southern hemisphere for April, May, and June 1967

7. MAINTAIN UBSO EQUIPMENT

7.1 MAGNETIC TAPE RECORDERS

A new set of Geotech magnetic tape-recorder heads was installed on recorder 1 on 23 October. The signal-to-tape noise ratio obtained using these heads is currently being evaluated.

A test of the speed of the magnetic-tape transports was made on 31 October. Tape recorders 2 and 3 were found to be out of tolerance, and their speeds were adjusted. The results of the test are shown in table 7.

Table 7. Results of tape transport speed test

Tape No.	Length of tape read	Reading time	Adjusted reading time
1	15 feet	9 min. 59 sec.	---
2	15 feet	10 min. 6 sec.	10 min. 1 sec.
3	15 feet	10 min. 5 sec.	10 min. 0 sec.
4	15 feet	9 min. 58 sec.	---

7.2 DEVELOCORDERS

Samples of water from several points in the UBSO water system and slime samples from the Develocorders were sent to the Western Filter Company, Denver, Colorado, for analysis and recommendations for the prevention of the slime formation. At the close of this reporting period, no results have been received.

7.3 CABLE

Nine, 6-reel lengths of spiral-four cable between the central recording building and the vertical array site were waterproofed with Kearney air seal on 19 August.

8. INSTRUMENT EVALUATION

8.1 EVALUATION OF VERTICAL ARRAY

As reported in section 2.2.4, the vertical array was inoperative during the reporting period; however, a study is currently in progress using previously-recorded vertical array data to relate observed attenuation of noise with depth to theoretically-predicted values.

8.2 TECHNICAL ASSISTANCE AND MONITOR OF SANDIA'S USO

Monitoring of the Sandia USO system continued throughout the reporting period. Sandia personnel were at UBSO on 21 September to replace a malfunctioning time code generator.

When the USO channels were switched to the Helicorder for the daily operational check on 4 October we discovered that the USO seismograph was inoperative. After the system had been recorded overnight and still found to be inoperative, Sandia Corporation was notified of the situation. Sandia personnel were at UBSO on 11 and 12 October to correct the malfunctioning seismograph. The trouble was traced to an amplifier that was saturated by the large earthquake near Richfield, Utah, on 4 October. A modification was installed that will prevent any future outages of this nature. The magnetic tape was changed, and the entire system checked during the Sandia visit.

9. SPECIAL INVESTIGATIONS

9.1 SIGNAL CLASSIFICATION STUDY

A study of a system for the classification of teleseismic earthquake signals was made in response to a need for a concise expression of the physical appearance of seismograms. In addition, a classification system based on the visual appearance of the signal could provide a means of focal mechanism discrimination.

The classification system investigated in this study describes a teleseismic signature by means of a seven-character, alphanumeric code. The seven characters of classification in order of decreasing generality, are as follows:

1. Four possible categories pertaining to the general shape of the signal envelope;

2. Ten possible categories concerned with the time lapse between the signal start and maximum;

3. Ten possible categories pertaining to the time lapse between the signal start and a secondary pulse;

4. Ten possible categories pertaining to the rate of buildup to the maximum;

5. Ten possible categories pertaining to the rate of buildup to a secondary pulse;

6. Eighteen possible categories pertaining to the rate of decay after the first principle pulse of the signal;

7. Six possible categories based on the amplitude of the maximum pulse relative to that of a secondary pulse.

One hundred and fifty-three earthquakes were selected which had epicenters at teleseismic distances from UBSO, TFSO, and WMSO, and whose magnitudes exceeded 5.0. The epicenter and magnitude data were taken from C&GS earthquake data reports of June through August 1966.

The recorded signals at each of the observatories were inspected, and those which had sufficient S/N to exhibit some definite signal character were classified by mutual agreement among a panel of Garland-based analysts. This resulted in a total of 247 signature classifications. These data were designated the "reference" set and were punched onto computer cards. The signatures from the various films were reproduced photographically and reassembled on one composite 16-millimeter film, ordered by date of origin. Copies of this classification study film were sent to UBSO and TFSO along with instructions for use of the system. Four TFSO and three UBSO analysts classified the signatures according to their understanding of the instructions. These classifications were recorded on standard computer data forms and were sent to the Garland facility where they were punched onto computer cards. The classifications of each of the seven categories for each of the seven analysts were compared with the reference classifications for all signals. Since the analysts did not necessarily use the same data trace (system) to classify a signal as did the reference, it was possible to make the comparison for the case of random trace selection by the analyst relative to the reference and for the case where both the analysts and the reference classified the signal from the same trace. To determine if experience in using the system improves the analyst's ability to classify a given signal correctly, the classifications made by two analysts who were experienced in using the system were compared to the reference. The results are summarized in table 8. The maximum percentage agreement with the reference upon a classification is obtained when the analysts are experienced in using

Table 8. Percent of agreement of analysts' classifications with the reference classifications

Source of reference classification	Source of analysts' classification	CHARACTER 1	2	3	4	5	6	7	Comments
Classifications made using various traces (systems)	Classifications made using the trace which, in the analyst's opinion, showed the signal character best	85.7	83.4	67.4	89.6	60.1	54.3	73.9	The analysts (7) were inexperienced in the use of classification system.
Same	Classifications made using the same trace as the reference	89.9	89.7	78.3	88.1	71.5	64.0	82.2	The analysts (7) were inexperienced in the use of classification system.
Same	Classifications made using the same trace as the reference	93.8	90.7	83.3	93.8	85.2	80.4	87.8	The analysts (2) were experienced in applying the system.

the system, and they use the same trace as that used during the reference classification. These conditions would be the normal ones if the system were used on a routine basis.

Table 8 shows percentage agreements with the reference for each of the seven character positions that constitute the complete signal classification. With the considerations of analysts experience and constancy of the trace used, good agreement is observed for most of the character positions; however, the percentage of agreement on the complete classification (all seven characters) is the product of the seven probabilities (assuming character independence) and is only about 40 percent.

Although the seven-character, alphanumeric system is adequate in the sense that the principle characteristics of the analog signal can be reproduced from the coded signal, it is too subjective in that a given signal cannot be identically classified upon subjection to repeated and independent analysis. The principal factor which introduces subjectivity into the system is that characters 1 through 6 are critically dependent upon the analyst's selection of the start time. A slight shift in the start time can cause a signal to fall into a different category.

We recommend that the seven-character, alphanumeric system be revised so that characters conveying the information now encoded by characters 1-6 would not be dependent upon the signal start. This change could be accomplished by keying on the signal maximum instead of the signal start. This modified classification system should be free of errors associated with picking the signal start time and should, as a result, permit identical classification of a signal under repeated, independent analysis. We also recommend that the modified system be evaluated to determine the degree to which the analog signal can be reproduced from the coded representation of the signal. The reproduction of the analog signal should be accomplished by machine processing to remove bias in the reproduction of the signals and also to evaluate possible routine reproduction of analog signals from codes received at a seismological data reduction center.

If the modified system proves to be sufficiently objective and capable of retaining the principal visual characteristics of a signal, we recommend that a number of signals of known but different source mechanism be classified and that these signals and the corresponding codes be examined to see if a particular type of source mechanism tends to produce signatures which are similarly classified.

9.2 ROUTINE NOISE MEASUREMENTS

Measurements of ambient noise in the 0.4 to 1.4 seconds period range are made daily at UBSO. Data are processed in Garland, and monthly cumulative

probability curves of trace amplitude and ground displacement data are published. Noise data are reported from the SZ10, ΣSS and ΣSSF seismograms. Noise curves for June, July, August, and September were sent to the Project Officer during this reporting period.

10. PROVIDE OBSERVATORY FACILITIES AND ASSISTANCE TO OTHER ORGANIZATIONS

10.1 DATA SENT TO THE UNIVERSITY OF UTAH AND TO C&GS

Analysis information was given to Mr. Waverly J. Persons, C&GS, and Mr. Larry Wilson, University of Utah, concerning a large earthquake that occurred near Richfield, Utah, on 4 October.

10.2 DATA SENT TO ESD

All 16-millimeter film and magnetic-tape seismograms with corresponding logs for 21 October were sent to Mr. Don Clark, ESD, on 25 October at the request of the Project Officer.

10.3 VISITORS

Messrs. E. D. Zaffery, P. A. Fjelseth, and E. R. Stepka, Sandia Corporation, were at UBSO on 16 and 17 August to work on the USO.

Messrs. R. S. Reynolds and E. D. Zaffery, Sandia Corporation, were at UBSO on 21 September to service the USO.

Captain Frederick D. Munzlinger, the VSC Project Officer, and Mr. B. B. Leichliter, Geotech Program Manager, visited UBSO on 28 and 29 September.

Messrs. P. A. Fjelseth and E. R. Stepka, Sandia Corporation, were at UBSO on 11 and 12 October for work on the USO.

On October 27, Messrs. John Wise and Noel Doss, Geotech, were at UBSO to work on the long-period triaxial seismograph system.

11. REPORTS

a. Technical Report No. 67-10, Operation of UBSO, Quarterly Report No. 5, Project VT/6705, was mailed to the Project Officer on 28 August.

b. Preparation of the draft of a technical report, Evaluation of Multiple Array Processors at the Uinta Basin Seismological Observatory, is in progress. The draft of this report will be submitted to the Project Officer for review during the week of 20 November.

APPENDIX to TECHNICAL REPORT NO. 67-73

STATEMENT OF WORK TO BE DONE

EXHIBIT "A"

STATEMENT OF WORK TO BE DONE

AFTAC Project Authorization No. VELA T/6705/S/ASD (32)

1. **Tasks:** 8 February 1966

a. **Operation:**

(1) Continue operation of the Uinta Basin Seismological Observatory (UBSO), normally recording data continuously.

(2) Evaluate the seismic data to determine optimum operational characteristics and make changes in the operating parameters as may be required to provide the most effective observatory possible. Addition and modification of instrumentation are within the scope of work. However, such instrument modifications and additions, data evaluation, and major parameter changes are subject to the prior approval of AFTAC.

(3) Conduct daily analysis of seismic data at the observatory and transmit daily seismic reports to the US Coast and Geodetic Survey, Wash DC 20230, using the established report format and detailed instructions.

(4) Record the results of daily analysis on magnetic tape in a format compatible with the automated bulletin program used by the Seismic Data Laboratory (SDL) in their preparation of the seismological bulletin of the VELA-UNIFORM seismological observatories. The format should be established by coordination with SDL through AFTAC. The schedule of routine shipments of these prepared magnetic tapes to SDL will be established by AFTAC.

(5) Establish quality control procedures and conduct quality control, as necessary, to assure the recording of high quality data on both magnetic tape and film. Past experience indicated that quality control review of one magnetic tape per magnetic tape recorder at the observatory each week is satisfactory unless quality control tolerances have been exceeded and the necessity of additional quality control arises. Quality control of magnetic tape should include, but need not necessarily be limited to, the following items:

(a) Completeness and accuracy of operation logs.

(b) Accuracy of observatory measurements of system noise and equivalent ground motion.

(c) Quality and completeness of voice comments.

(d) Examination of all calibrations to assure that clipping does not occur.

(e) Determination of relative phase shift on all array seismographs.

(f) Measurement of DC unbalance.

(g) Presence and accuracy of tape calibration and alignment.

(h) Check of uncompensated noise on each channel.

(i) Check of uncompensated signal-to-noise of channel 7.

(j) Check of general strength and quality of timing data derived from National Bureau of Standards Station WWV.

(k) Check of time pulse modulated 60 cps on channel 14 for adequate signal level and for presence of time pulses.

(l) Check of synchronization of digital time encoder with WWV.

(6) Provide observatory facilities, accompanying technical assistance by observatory personnel, and seismological data to requesting organizations and individuals after approval by AFTAC.

(7) Maintain, repair, protect, and preserve the facilities of the seismological observatory in good physical condition in accordance with sound industrial practice.

b. <u>Instrument Evaluation</u>: After approval by AFTAC, evaluate the performance characteristics of experimental or off-the-shelf equipment offering potential improvement in the performance of observatory seismograph systems. Operation and test of such instrumentation under field conditions should normally be preceded by laboratory test and evaluation.

c. <u>Special Investigations</u>: Conduct research investigations as approved or requested by AFTAC to obtain fundamental information which will lead to improvements in the detection capability of UBSO. These programs should take advantage of geological, meteorological, and seismological conditions at UBSO. The following special studies should be accomplished.

(1) Long term evaluation of the multiple array processor units.

(2) Installation and evaluation of a vertical array.

(3) Evaluation of the long-period vault.

(4) Provide technical assistance and monitor an unattended seismological observatory to be installed at UBSO in June 1967.

Research might pursue investigations in, but is not necessarily limited to, the following areas of interest: microseismic noise, signal characteristics, data presentation, detection threshold, and array design (surface and shallow borehole). Prior to commencing any research

investigation, AFTAC approval of the proposed investigation and of a comprehensive program outline of the intended research must be obtained.

2. Approval by AFTAC will normally be provided through the project officer.

3. Reports: Provide reports in accordance with the/Data requirements outlined in DD Form 1423 and attachment 1 thereto.

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency Nuclear Test Detection Office Washington, D. C.

13. ABSTRACT

This report describes the operation of the Uinta Basin Seismological Observatory (UBSO) from 1 August through 31 October 1967. Modifications and additions to the observatory instrumentation are described, and tests to improve the operations of the observatory are reported. Also discussed is the status of special investigations designed to evaluate and improve the detection capability of the observatory.

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